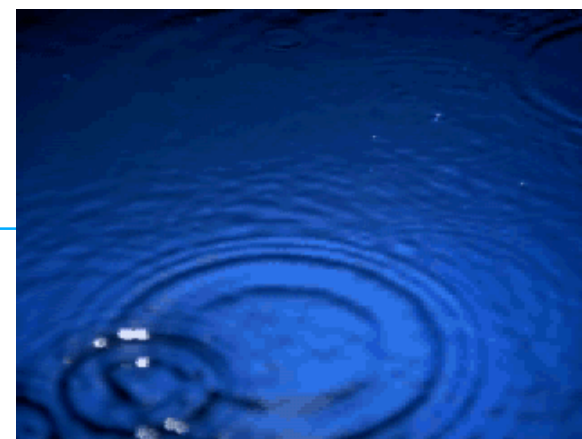


Global Precipitation Measurement

System Definition Review System Engineering Process

December 6-8, 2005



*David Bundas 301/286-5573
David.Bundas@gsfc.nasa.gov
V
Goddard Space Flight Center*

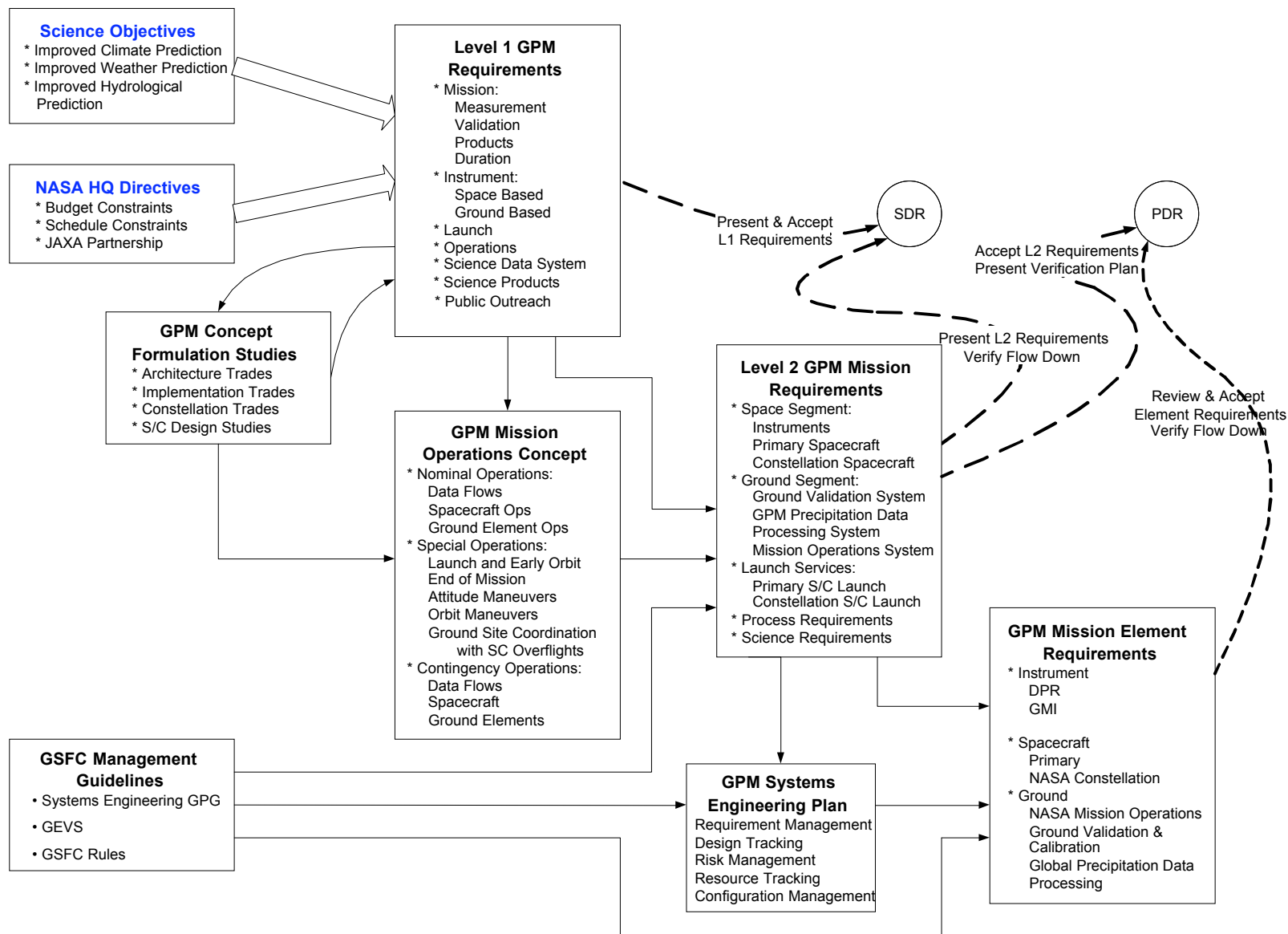


- ***Systems Engineering Team***
- ***Systems Engineering Management Plan (SEMP)***
- ***Requirements Development, Flow Down, & Tracking***
- ***Verification***
- ***GSFC Rules Process***
- ***Engineering Peer Reviews***
- ***Risk Management***
- ***Systems Engineering Status***



- *Debbie O'Neill/599 - Core Spacecraft Systems Engineer*
- *Dave Bundas/599 - Constellation Spacecraft Systems Engineer*
- *Tom Toutsis/303 - System Assurance Manager*
- *Tin Lee/565 - Electrical Systems*
- *Jay Parker/543 - Mechanical Systems*
- *Greg Greer/545 - Thermal Systems*
- *Carver Audain/582 - Software Systems*
- *Steve Bidwell/556 - GMI Instrument Systems*
- *Clyde Woodall/420.2 - DPR/LV Interface Manager*
- *Judy Brannen/SAI - Requirements*
- *Veronica Caprara/BAH - Risk Manager*
- *Tom Field/599 - Verification*
- *Nino Ingegneri/302.9, Lydia Lee/302 - Reliability*
- *Pete Patterson/SAI - Technical Resource Budgets*
- *Larry Ramsey/546 - Contamination Control*
- *Mike Rhee/599 - Systems Engineering*
- *Tim Rykowski/581 - Ground System Engineering*
- *Jay Spero/610.2 - Ground Data Systems*
- *Clyde Woodall/420.2 - External Interfaces*



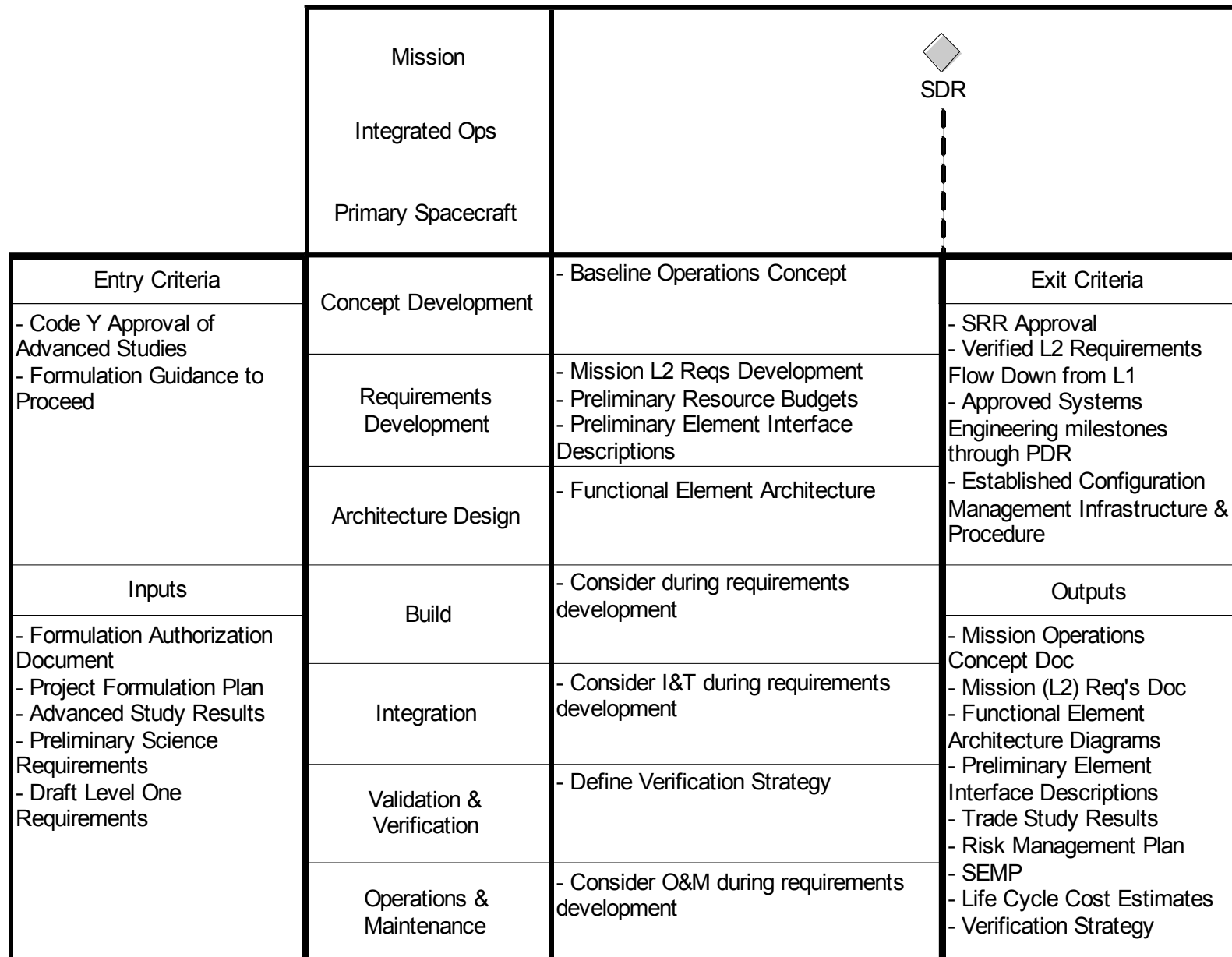


- **System Engineering Management Plan (GSFC 420.2-02-001-01)**
 - Describes the Time-phased Plan for System Engineering for GPM
 - Original release covered through SRR.
 - Updated to detail events up to PDR, and to comply with GPR7120.5A, Systems Engineering
- **Process described by phase of development and specific activities**
- **Each phase detailed with entry criteria, exit criteria, inputs, outputs, and tasks**
- **Each phase describes responsibilities for element engineers.**



		Formulation		Implementation		Operations	
Control Gates	Mission	SDR		PDR		CDR	
	Integrated Ops					MOR	
	Primary Spacecraft					FOR	
						Pre-Env	
						Pre-Ship	
						OPR	
Systems Engineering Activities	Concept Development	- Baseline Operations Concept	- Detailed Element Concept Development	- Detailed Subsystem Concept Development			
	Requirements Development	- Mission L2 Reqs Development - Preliminary Resource Budgets - Preliminary Element Interface Descriptions	- Element L3 Reqs Development - Subsystem L4 Reqs Development - Baseline Resource Budgets - Subsystem ICDs	- Resource Budgets	- Define Configuration Requirements/ Data Dictionary		- Operational Feedback to Requirements
	Architecture Design	- Functional Element Architecture	- Functional Subsystem Architecture	- Physical Component Architecture - Physical Schematic Architecture			
	Build	- Consider during requirements development	- Identification of long lead production items	- Prototype and demonstration - Initiate acquisition for long lead production items	- Develop and integrate components		- As Built Documentation
	Integration	- Consider I&T during requirements development	- Preliminary I&T Plan	- I&T Plan	- Execute I&T for Prime S/C, Ground Systems, GVS, and SDPS		- Assess I&T Process
	Validation & Verification	- Define Verification Strategy	- Validate L2 Requirements (Is the correct system being designed?) - Baseline Verification Method Plan	- I&T Plan - Validate L3/L4 Requirements	- Verify System Against Requirements (Has the correct system been built?) - Track Resource Budgets		- Validate L1 Requirements (Is the mission successful?) - Verify Models vs. Operational Data - Resource Budget Feedback
	Operations & Maintenance	- Consider O&M during requirements development	- Preliminary Operations Plan	- Mission Operations Plan - Draft Procedures - Contingency Plans	- Simulation Support - Procedure Finalization and Validation		- Operations - Anomaly Resolution - Data Processing and Delivery
Enabling Activities	Trade Studies	- Operations Concept Trades - Element Requirements Trades - Architecture Trades	- Subsystem Requirements Trades - Architecture Trades	- Operations Architecture Trades			
	Peer Reviews (Mission SE and Element)	- Support System Definition and Team definition	- Support Component Level Decision	- Focus on Operations and Mission Integration	- Focus on Prime S/C I&T - Operations Readiness - Ground Validation Site Performance		- Assess Process
	Communications	- Define engineering teams - Establish Toolset for Req, Arch, Knowledge Capture, Mod & Sim	- Focus on element requirements, architecture, subsystem interfaces - SLATE Prime for Req and Arch	- Component definition and detailed design	- Focus on Systems Integration		- Assess Process
Engineering Management and Control	Risk Management	- Define Risk Management Process - Define Risk Assessment Process - Identify Mission, Element Level Risks	- Identify Subsystem Level Risks - Define Mitigation Techniques - Track Risks and Mitigation	- Identify Component Level Risks - Track Risks and Mitigation - Retire Risks	- Retire Risks		- Track Operational Risks
	Reliability Assessment	- Consider Reliability during requirements development	- Preliminary Reliability assessment at component level	- Validate against reliability requirements	- Test against reliability requirements		- Verify Reliability Models against Operational Data
	Configuration Management	- Define CM Process - Establish CM in Requirements and Trades	- Establish CM in Architecture and Reliability	- Establish CM in I&T processes	- Establish CM in Operations processes		- Assess Process

GPM Systems Engineering Process Overview

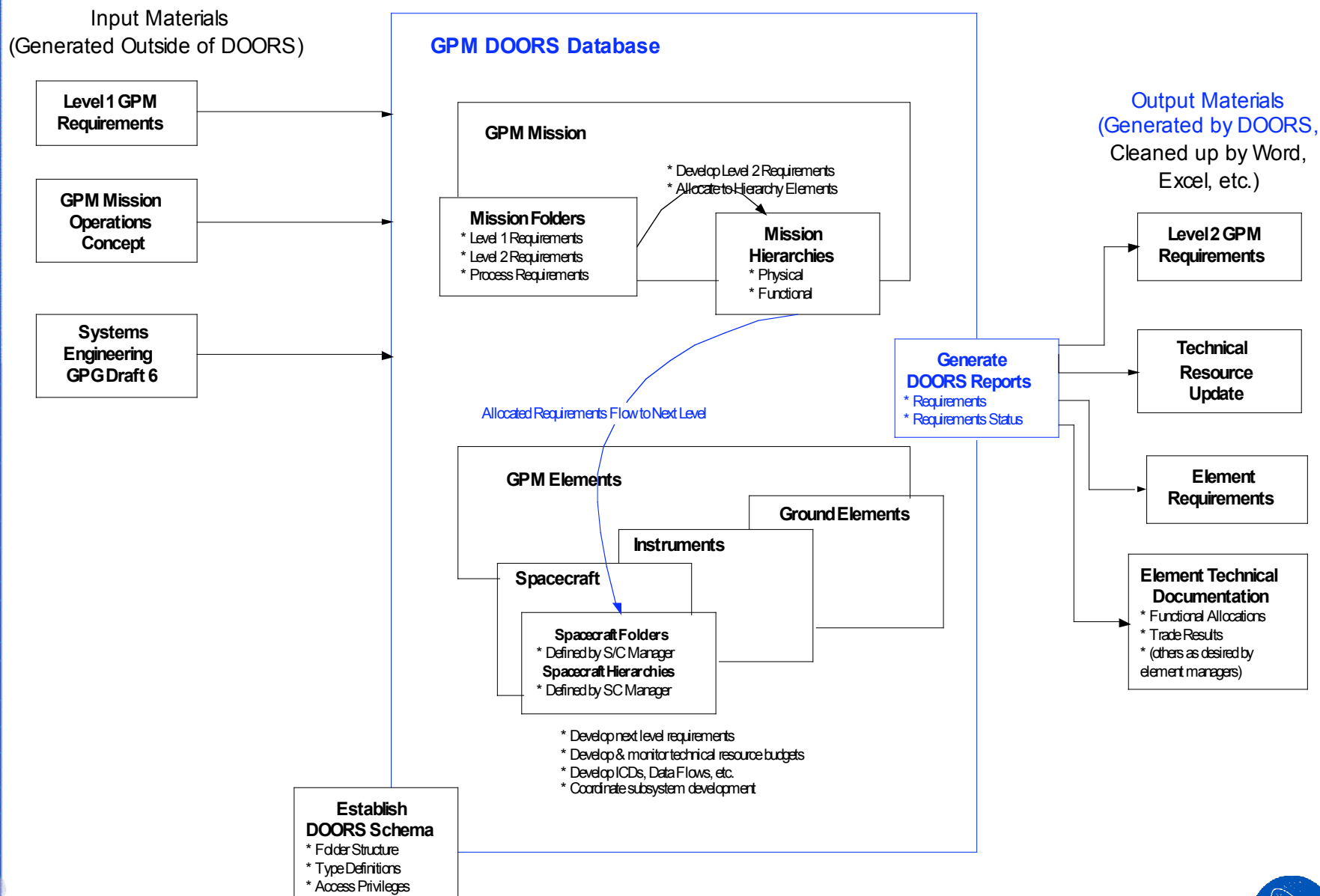


SEMP Process, Pre-SDR Team Responsibilities

	Mission SE	Ground Validation SE	Precipitation Processing SE	Mission Operations SE	Primary Spacecraft SE	Constellation Spacecraft SE	Instrument SE
Concept Development	<ul style="list-style-type: none"> Lead coordination and development Modify Ops Concept Document 	<ul style="list-style-type: none"> Provide Input 	<ul style="list-style-type: none"> Provide Input 	<ul style="list-style-type: none"> Provide substantial input 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide Input 	<ul style="list-style-type: none"> Provide Input
Requirements Development	<ul style="list-style-type: none"> Provide guidance Ensure communication Develop preliminary interface definitions Make mission level decisions 	<ul style="list-style-type: none"> Develop L2 Ground Validation System Reqs. Define reqs. imposed on other elements Provide preliminary interface input 	<ul style="list-style-type: none"> Develop L2 PDPS Reqs. Define reqs. imposed on other elements Provide preliminary interface input 	<ul style="list-style-type: none"> Develop L2 Ground Operations Reqs. Define reqs. imposed on other elements Provide preliminary interface input 	<ul style="list-style-type: none"> Develop L2 Primary S/C Reqs. Define reqs. imposed on other elements Determine Preliminary Resource Budgets Provide preliminary interface input 	<ul style="list-style-type: none"> Develop L2 Constellation S/C Reqs. Define reqs. imposed on other elements Provide Preliminary Resource Budgets Provide preliminary interface input 	<ul style="list-style-type: none"> Develop L2 Instrument Reqs. Define reqs. imposed on other elements Provide preliminary interface input
Architecture Design	<ul style="list-style-type: none"> Perform functional architecture design for subsystems 	<ul style="list-style-type: none"> Provide architecture options 	<ul style="list-style-type: none"> Provide architecture options 	<ul style="list-style-type: none"> Provide architecture options 	<ul style="list-style-type: none"> Provide architecture options 	<ul style="list-style-type: none"> Provide architecture options 	<ul style="list-style-type: none"> Provide architecture options
Build	<ul style="list-style-type: none"> Ensure team consideration 	<ul style="list-style-type: none"> Consider element build feasibility 	<ul style="list-style-type: none"> Consider element build feasibility 	<ul style="list-style-type: none"> Consider element build feasibility 	<ul style="list-style-type: none"> Consider element build feasibility 	<ul style="list-style-type: none"> Consider element build feasibility 	<ul style="list-style-type: none"> Consider element build feasibility
Integration	<ul style="list-style-type: none"> Ensure team consideration 	<ul style="list-style-type: none"> Consider element testability 	<ul style="list-style-type: none"> Consider element testability 	<ul style="list-style-type: none"> Consider element testability 	<ul style="list-style-type: none"> Consider element testability 	<ul style="list-style-type: none"> Consider element testability 	<ul style="list-style-type: none"> Consider element testability
Validation & Verification	<ul style="list-style-type: none"> Develop Verification Strategy 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide input 	<ul style="list-style-type: none"> Provide input
Operations & Maintenance	<ul style="list-style-type: none"> Ensure team consideration 	<ul style="list-style-type: none"> Consider O&M 	<ul style="list-style-type: none"> Consider O&M 	<ul style="list-style-type: none"> Consider O&M Provide O&M input to Ops Concept 	<ul style="list-style-type: none"> Consider O&M 	<ul style="list-style-type: none"> Consider O&M 	<ul style="list-style-type: none"> Consider O&M

- **Telelogic DOORS® Requirements Management Tool**
(<http://www.telelogic.com/corp/products/doors/doors/index.cfm>)
- **Telelogic DOORS is the world's leading requirements management tool, it is a multi-platform system designed to capture, link, trace, analyze and manage changes to information to ensure a project's compliance to specified requirements and standards.**
 - Telelogic continues strong support for the software.
 - Corporate usage in this industry Lockheed Martin, Boeing, Raytheon, BAE Systems.
- **More than simply a requirements management tool**
 - Architecture based
- **Interfaces to standard tools**
 - Excel
 - Word
 - Visio
- **Doors is used on center by SDO, JWST, GOES, ST8, LRO.**





- L1 Traceability Completed
 - All L1 have identified flowdowns
- L2 Traceability Completed
 - All L2 have identified flowdowns
- Traceability Reports Available for Review



LEVEL 1 TRACEABILITY REPORT @GPM SDR

Parent RQMT #	Parent RQMT Section	Parent RQMT	RQMT #	L1 RQMT Section	L1 RQMT Heading	Child RQMT #	Child RQMT Section	Child RQMT Heading
				2.2.2	Project Elements	HQ113 HQ69 HQ70 HQ71 HQ72	3.1.2.5 3.1.3.1 3.1.3.2 3.1.3.3 3.1.3.4	NASA Provided Spacecraft Spacecraft Monitoring and Control Science Data Handling Precipitation Processing System (PPS) Ground Validation System (GVS)
	2.2.2	Project Elements		3.1.3.1	Spacecraft Monitoring and Control	MRD411 MRD413 MRD415 MRD425	7.1.15 7.1.16 7.1.17 7.1.22	Interface to Flight Segment Interface to Flight Dynamics Facility Interface to Launch Sites Health and Safety Monitoring

LEVEL 2 TRACEABILITY REPORT DEC 03 2005

Section #	Parent Object Heading		Level 2 Requirement		Level 3 Requirement
3.1.3.1	Spacecraft Monitoring and Control	7.1.15 7.1.15	Interface to Flight Segment	SN SVCS 03100 SN SVCS 03200	SN -- One way Doppler service SN -- Differential One-Way Doppler Service
3.1.3.1	Spacecraft Monitoring and Control	7.1.16	Interface to Flight Dynamics Facility	FDF 00100	FDF ephemeris determination for TDRSS
3.1.3.1	Spacecraft Monitoring and Control	7.1.17	Interface to Launch Sites	DCPROC 00350	Source Packet extraction



- ***GSFC-STD-1000, Rules for the Design, Development, Verification, and Operation of Flight Systems, Rev. A, May 30, 2005***
- ***Captured in DOORS***
 - *By project phase*
- ***Reviewed by Systems Engineering for applicability by Element***
- ***Element leads report on compliance***
- ***Report at each major review status of compliance***
- ***Rule compliance issues to be resolved by PDR (comply or waive)***
 - *1.14 Mission critical telemetry - Potential SC transmitter interference with H2 LV*
 - *4.23 Life Testing - Demisable Reaction Wheel, GMI BAPTA under study*
- ***Form GSFC 4-39, Goddard Rules Compliance Matrix to be submitted to GSFC Office of Mission Success for concurrence prior to PDR***

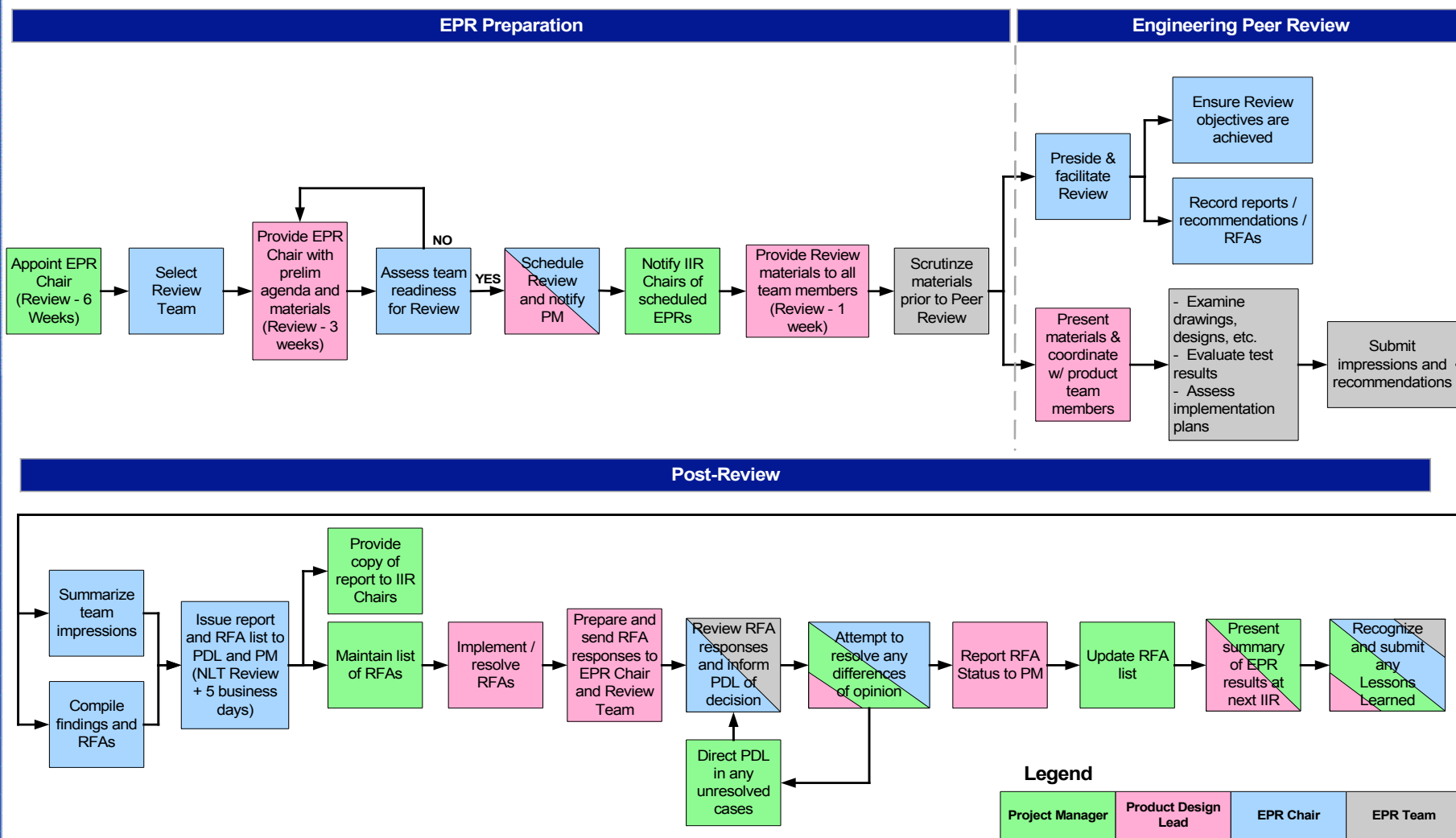


- **Requirements Tracking and control process includes use of DOORS database to insure no orphan requirements and proper traceability and flow down.**
- **Verification Tracking using DOORS database will include the following fields**
 - Ownership to identify which individual(s) is(are) responsible for verifying this requirement
 - Verification method; Inspection / Analysis / Demonstration / Test
 - Verification Documentation to show where the requirement is verified
 - Verification Result Summary
- **Mission Verification Plan will define overall process and plan for completion.**
 - Will contain the approach for both Environmental & Performance Verification per GSFC-STD-7000 (GEVS)
 - Defines what tests are performed at what level and which verifications are accomplished at each test
 - Defines creation of Mission verification matrix which will record component and subsystem level verifications completed and establish required testing at system level during I&T.

Signoff prior to RDR

- ***Engineering Peer Review Plan (EPRP) was prepared in accordance with the Goddard Procedural Requirements (GPR) document governing Engineering Peer Reviews (GPR 8700.6A)***
- ***Describes Engineering Peer Review (EPR) process that GPM will utilize throughout the mission's life cycle***
- ***Project will coordinate the logistics for managing recordkeeping***





- **System Engineering Peer Reviewers: Dave Everett (Chair), Steve Leete, Cindy Firman, Ken Yienger (Ops Concept)**
- **SE Peer Reviews**
 - 22Sep05 - Operations Concept*
 - 07Oct05 - L1/L2 Requirements*
 - 21Oct05 - Architecture and Budgets*
 - 22Nov05 – SEMP*
- **All comments from reviews addressed in updated documents**
 - *Updated Mission/Core Spacecraft Operations Concept Documents*
 - *Updated L1/L2 Requirements Documents*
 - *Updated Architecture and Technical Resource Budgets*
 - *Updated SEMP*



- **Engineering Peer Reviews Prior to Mission PDR**

- Systems Engineering
- SC Structure
- SC Thermal
- SC HGAS
- SC Propulsion
- SC Power Systems
- SC GNC (including RWA)
- GMI Spin Mechanism Assembly (SMA)
- Observatory I&T
- Avionics Package Design
 - FSW, GNC, Power, RF Comm., C&DH, Mechanical/Thermal
- MOS Design
- Ground System Requirements
- GVS
- PPS Build 1 Review



- ***Risk: The combination of the probability that a project will experience an undesired event and the impact of the undesired event, were it to occur***
- ***A risk has three components:***
 - *Probability of occurring*
 - *Impact if it were to occur*
 - *Timeframe in which action must be taken*
- ***Features of Continuous Risk Management (CRM):***
 - *Risk Identification & Characterization*
 - *Analysis*
 - *Planning*
 - *Tracking*
 - *Controlling*
 - *Documenting and Communicating*
- ***Risk Management Plan under CM***
- ***PRIMX tool will be used for Risk Tracking***



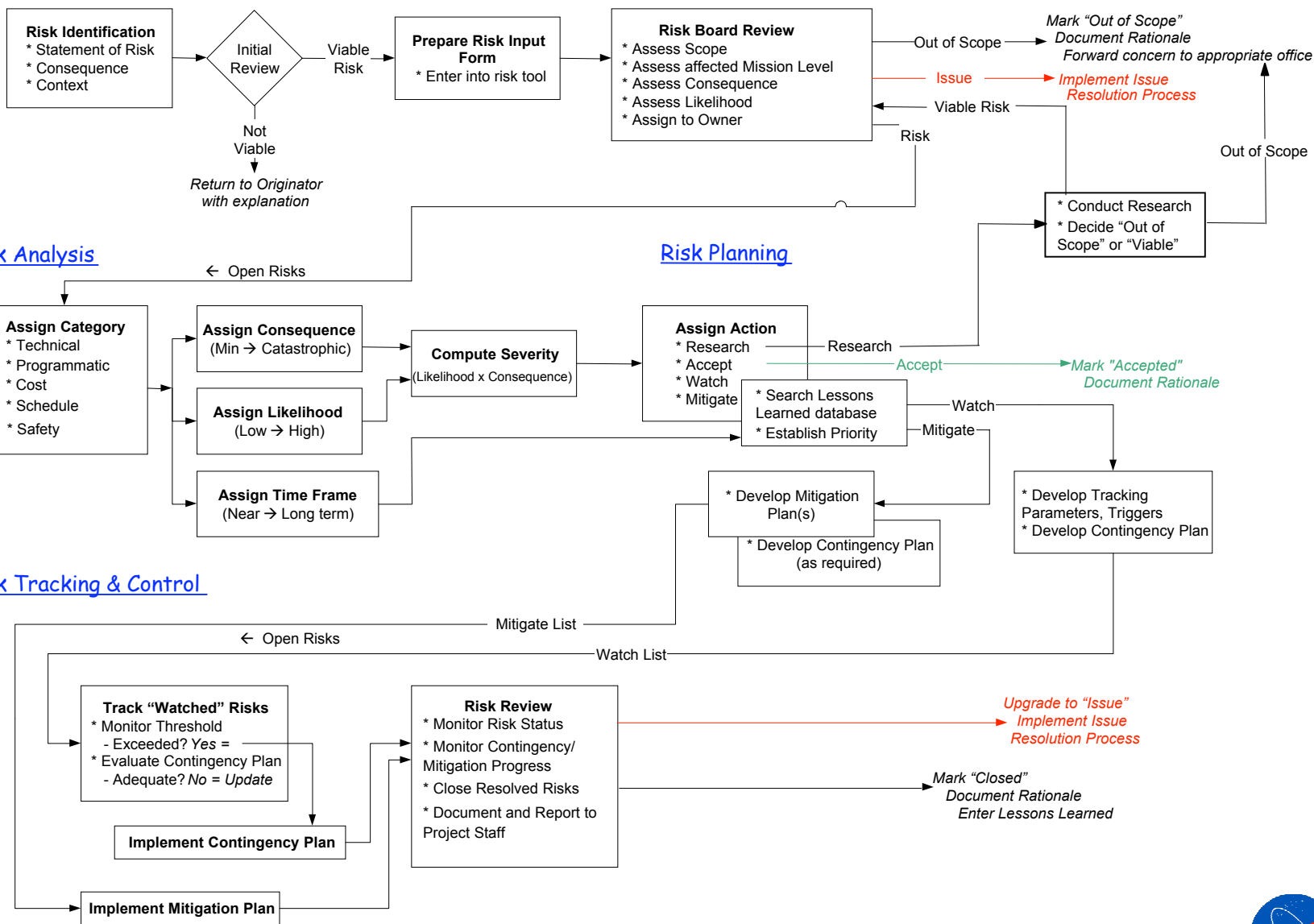
Risk Identification & Characterization

Risk Disposition

Risk Analysis

Risk Planning

Risk Tracking & Control



- **Requirements:**
 - Level 1 Requirements Document Ready for Acceptance
 - Level 1 Requirements Entered into DOORS and Allocated to Mission Elements
 - Level 2 Requirements identified and allocated within DOORS
 - Draft Level 2 Requirements Document available for review
 - Draft Level 3 Requirements Documents available for review
- **Risk Management program established and on-going assessment at mission & element level**
- **Revised SEMP is ready for sign-off**
- **Engineering Peer Review Plan has been revised and is under review by team**
- **Mission Design:**
 - Architecture and Mission Concept largely unchanged, with draft operations concept documents available for review



- **Exit Criteria**

- *SDR Approval—In work*
- *Verified L2 Req flow down from L1—Done via DOORS*
- *Approved Systems Engineering milestones through PDR - Under Review*
- *Established CM infrastructure and procedure - 422-PG-1410.2.1*

- **Outputs**

- *Mission Operations Concept Document—Draft available, sign Jan 2006*
- *Mission (L2) Requirements Document - Ready for signature after SDR inputs*
- *Functional Element Architecture Diagrams—SRR presentation*
- *Preliminary Element Interface Descriptions—SRR presentation*
- *Trade Study Results—SRR presentation*
- *Risk Management Plan - Signed off, under revision.*
- *SEMP—signed-off version updated - ready for CM*
- *Life Cycle Cost Estimates—presented on Thursday*
- *Verification Strategy—SRR presentation*



Day 1 - December 6, 2005

Location: NASA GSFC B16W-N76/80

Time	Section	Event	Presenter
8:30 AM		Logistics & Announcements	Durning
8:35 AM	1	Introduction	Durning/Ho
8:45 AM		Charge to Review Team/RIDs: Purpose & Review Criteria	Ho
8:55 AM		HQ Overview	Neeck
9:10 AM	2	GPM Mission Overview	Durning
9:55 AM	3	Science Requirements	Hou
10:25 AM		Break	
10:40 AM	4	Mission Requirements	Bundas
11:10 AM	5	Mission Architecture	Bundas
11:55 AM		Lunch	
12:55 PM	6	Systems Engineering Processes	Bundas
1:40 PM	7	System Safety and Mission Assurance	Touts
1:55 PM	8	External Interfaces	Hwang
2:10 PM	9	Dual Precipitation Radar (DPR) Overview/Requirements	Woodall
2:55 PM		Break	
3:10 PM	10	GPM Microwave Imager (GMI) Overview/Requirements	Flaming/Bidwell
4:10 PM	11	H-IIA Launch Vehicle	Woodall
4:30 PM		Review Team Caucus	
4:40 PM		End of Day 1	

